FORM PTO-1390 (REV 12-29-99)

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER: 11848/4

U.S. APPLICATION NO. (If known, see 37 CFR 1.5): 10/019237

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/AU00/00836	July 12, 2000	July 12, 1999

TITLE OF INVENTION: AN ENERGY STORAGE DEVICE

APPLICANT(S) FOR DO/EO/US: MAHON, Peter John

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☑ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☑ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☑ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☑ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☑ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☑ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☑ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☑ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☑ A FIRST preliminary amendment.
    ☐ A SECOND or SUBSEQUENT preliminary amendment.
14. ☐ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☐ Other items or information:

U.S. APPLICATION NO (if known, see 37 CFR 1.5)	INTERNATIONAL APPLICATION NO	ATTORNEY'S DOCKET NUMBER
10/019237	PCT/AU00/00836	11848/4

17. ☑ The following fees are submitted:	CALCULATIONS PTO USE ONLY	
BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :		
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO **$970.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO **$840.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO **$690.00**		
International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) **$670.00**		
International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) **$96.00**		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 1,040.00	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$ -0-	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	10 - 20 =	0	X **$18.00**	$ 0.00	
Independent claims	3 - 3 =	0	X **$78.00**	$ -0-	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ **$260.00**	$ -0-	
TOTAL OF ABOVE CALCULATIONS =				$ 0.00	
Reduction of 1/2 for filing by small entity, if applicable. A Small Entity Statement must also by filed (Note 37 CFR 1.9, 1.27, 1.28).				$ 520.00	
SUBTOTAL =				$ 520.00	
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$ -0-	
TOTAL NATIONAL FEE =				$ 520.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$ -0-	
TOTAL FEES ENCLOSED =				$ 520.00	
				Amount to be refunded:	$
				charged:	$

a. ☐ A check in the amount of $_____ to cover the above fees is enclosed.

b. ☑ Please charge my Deposit Account No. 11-0600 in the amount of $520 to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☑ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 11-0600. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO.
William K. Wells, Esq.
KENYON & KENYON
1500 K Street, N.W., Suite 700
Washington, DC 20005

Tel.: (202) 220-4200
Fax: (202) 220-4201

SIGNATURE

John C. Altmiller

NAME

Reg. No. 25,951

REGISTRATION NUMBER

PATENT

Docket No. 11848/4

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s)	:	Peter John MAHON
Serial No.	:	(Natl. Phase of PCT/AU00/00836)
Filed	:	28 December 2001
For	:	AN ENERGY STORAGE DEVICE
Art Unit	:	Unassigned
Examiner	:	Unassigned

ASSISTANT COMMISSIONER
FOR PATENTS
Washington, D.C. 20231

PRELIMINARY AMENDMENT

SIR:

Prior to examining the above-identified national phase patent application, please amend the application as follows.

In the Claims:

Please cancel claims 1-40 and add new claims 41-50, as follows:

41. An energy storage device including:

a housing having two terminals;

an electrochemical device disposed within the housing for providing an electrical potential between the terminals; and

a first capacitor mounted to the housing and being electrically connected to the terminals in parallel with the electrochemical device.

42. An energy storage device according to claim 41 wherein the capacitor is an electric double layer supercapacitor including:

a capacitor housing;

a first and a second opposed sheet electrodes disposed within the housing and being respectively electrically connected to the terminals;

a separator located between the electrodes; and

an electrolyte intermediate the electrodes for allowing charge to be stored at the electrodes.

43. An energy storage device according to claim 41 wherein the capacitor is flexible and wrapped about the housing.

44. An energy storage device according to claim 41 wherein the electrochemical device and the capacitor each include a power density and an energy density, wherein the energy density of the electrochemical device is greater than the energy density of the capacitor and the power density of the electrochemical device is less than the power density of the capacitor.

45. An energy storage device including:

a housing having two terminals; and

a first capacitor forming part of the housing and connected to the terminals.

46. An energy storage device according to claim 45 wherein the housing has a form factor corresponding or being related to battery size designations N, AAAA, AAA, AA, C or D.

47. An energy storage device according to claim 45 wherein the capacitor is an electric double layer supercapacitor including:

a capacitor housing;

a first and a second opposed sheet electrodes disposed within the housing and being respectively electrically connected to the terminals;

a separator located between the electrodes; and

an electrolyte intermediate for allowing charge transfer between the electrodes.

48. An energy storage device including:

a housing having an interior and an exterior where the interior defines a cavity;

two terminals disposed on or adjacent to the exterior of the housing for electrically engaging with respective terminals of a load that requires a predetermined load current;

an electrochemical device disposed within the cavity and being electrically connected to the terminals for providing a first current to the load; and

a capacitor disposed within the cavity and being electrically connected to the terminals in parallel with the electrochemical device for providing a second current to the load, whereby the first current and the second currents collectively sum to the predetermined load current.

49. An energy storage device according to claim 48 wherein the electrochemical device includes an anode and a cathode that are respectively fixedly electrically connected to the terminals by way of an anode tab and a cathode tab, and the capacitor includes a positive electrode and a negative electrode that are respectively fixedly electrically connected to the terminals by way of a positive electrode tab and a negative electrode tab.

50. An energy storage device according to claim 48 wherein the capacitor is an electric double layer supercapacitor including:

a capacitor housing;

a first and a second opposed sheet electrodes disposed within the housing and being respectively electrically connected to the terminals;

a separator located between the electrodes; and

an electrolyte intermediate for allowing charge transfer between the electrodes.

REMARKS

Claims 1-40 have been canceled and new claims 41-50 were added. No new matter has been introduced.

Examination in light of these amendments is respectfully requested.

The Office is hereby authorized to charge any additional fees or credit any overpayments under 37 C.F.R.§1.16 or §1.17 to Deposit Account No. 11-0600. The Examiner is invited to contact the undersigned at 202-220-4247 to discuss any matter regarding this application.

Respectfully submitted,

KENYON & KENYON

Dated: 28 December 2001

John C. Altmiller
(Reg. No. 25,951)

KENYON & KENYON
1500 K Street, N.W., Suite 700
Washington, DC 20005

Tel.: (202) 220-4200
Fax: (202) 220-4201

393254

TITLE: **AN ENERGY STORAGE DEVICE**

The present invention relates to an energy storage device.

The invention has been developed primarily for providing an energy store for portable electrical devices such as mobile telephones and laptop computers and will be described hereinafter with reference to that application. However, the invention is not limited to that particular field of use and is also applicable to other electrical loads including those that are remote from mains supplies or those that have high peak currents and low average currents.

BACKGROUND OF THE INVENTION

Dry cell and alkaline batteries, both in primary and secondary form, are used in a wide variety of applications. Primary batteries are once only or disposable batteries, while secondary batteries are rechargeable. Batteries of these kinds are used in mobile and cellular telephones, portable computers, cordless electric power tools, household appliances, cameras, and other mobile devices to name but a few. These form of batteries are preferred as they provide a relatively high energy density and are relatively inexpensive. The latter is of particular importance for primary cells which are, in effect, consumables.

Batteries are either primary and secondary sources and can be either wet or dry cell. Some of the commonly available types are alkaline, Lithium ion, Lithium polymer, Nickel Metal Hydride, Nickel Cadmium or Carbon Zinc. Of the primary batteries, the most common batteries are in the form of cylindrical cells, each of which provides a potential of about 1.5 Volts. A number of such cells are generally connected in series to provide the necessary voltage for the device concerned. These

cells are specified by size categorisations, which are designated, for example, as N, AAAA, AAA, AA, C and D. Other prismatic forms are also available.

These batteries suffer from several limitations including poor accommodation of wide variations in load currents and a low efficiency at high load currents. Accordingly, in circumstances where a constant load current is drawn, such as in a torch, a battery is an ideal source of energy. However, where varying load currents, and particularly high load currents for high power applications are encountered, the battery life becomes compromised. For example, when a power tool, such as an electric drill, is operating at a constant low current to provide a given torque, the battery is efficiently providing the necessary energy requirements. However, should the operator require a higher torque for a short period, a pulse or surge of power will be required. Although this demand for transitory power is common in many electrical appliances and devices, it is not efficiently provided by a battery. There are a number of strategies that are adopted to overcome this inherent compromise. For the example of the electric drill, it is known to make use of adjustable gearing to provide a wider range of available torque.

Similar problems to that foreshadowed above for the drill arise for other devices whether they are toys, electronic games, mobile or cellular phones, portable or laptop computers or the like. In an attempt to address this limitation it has been known to provide a battery having a slightly lower internal resistance. However, this form of battery design compromises the energy density of the resultant battery.

SUMMARY OF THE INVENTION

It is an object of the present invention to overcome or ameliorate at least one of

the disadvantages of the prior art, or to provide a useful alternative.

According to a first aspect of the invention there is provided an energy storage device including:

a housing having two terminals;

an electrochemical device disposed within the housing for providing an electrical potential between the terminals; and

a first capacitor mounted to the housing and being electrically connected to the terminals in parallel with the electrochemical device.

Preferably, the capacitor extends about the housing. More preferably, the housing is cylindrical and extends between two opposed axially spaced apart ends, whereby the ends define respective terminals and the capacitor extends about the housing intermediate the ends.

Preferably also, the capacitor is an electric double layer supercapacitor including:

a capacitor housing;

a first and a second opposed sheet electrodes disposed within the housing and being respectively electrically connected to the terminals;

a separator located between the electrodes; and

an electrolyte intermediate the electrodes for allowing charge to be stored at the electrodes.

In a preferred form, the capacitor is flexible and wrapped about the housing. However, in other embodiments, the capacitor is flexible and configured as a tube that

is disposed within the housing. Preferably, in either case, the capacitor is wrapped around the electrochemical device.

Preferably, the electrochemical device is generally cylindrical and extends between two opposed axially spaced apart ends and the first capacitor extends axially away from one of the ends. More preferably, the energy storage device includes a second capacitor which has an aperture for receiving the electrochemical device.

In a preferred form, the aperture receives both the electrochemical device and the first capacitor. More preferably, the second capacitor is tubular and extends about the first capacitor and the electrochemical device.

Preferably, the electrochemical device is a battery and the capacitor is an electric double layer supercapacitor. More preferably, the battery is a Li-Ion battery that has a solid electrolyte. Even more preferably, the electrolyte includes a polymer.

Preferably also, the electrochemical device and the capacitor each include a pair of electrodes that are electrically connected to the respective terminals. More preferably, the electrodes are fixedly connected to the respective terminals. However, in some embodiments, at least one of the electrodes of the supercapacitor are selectively electrically isolated from the terminals. In the case of the latter, it is preferred that the energy storage device includes a switch that is electrically disposed between one of the terminals and one of the electrodes of the capacitor for effecting the selective electrical isolation.

The electrochemical device and the capacitor each include a power density and an energy density. Preferably, the energy density of the electrochemical device is

greater than the energy density of the capacitor and the power density of the electrochemical device is less than the power density of the capacitor.

According to a second aspect of the invention there is provided an energy storage device including:

a housing having two terminals; and

a first capacitor forming part of the housing and connected to the terminals.

Preferably, the housing has a form factor corresponding or being related to battery size designations N, AAAA, AAA, AA, C or D.

More preferably, an electrochemical device is disposed within the housing for providing electrical energy to the terminals. More preferably, the electrochemical device extends about the housing.

Preferably also, the housing is cylindrical and extends between two opposed axially spaced apart ends, whereby the ends define respective terminals and the capacitor extends about the housing intermediate the ends.

Preferably, the capacitor is an electric double layer supercapacitor including:

a capacitor housing;

a first and a second opposed sheet electrodes disposed within the housing and being respectively electrically connected to the terminals;

a separator located between the electrodes; and

an electrolyte intermediate the electrodes for allowing charge to be stored at the electrodes.

In a preferred form, the capacitor is flexible and wrapped about the housing. However, in other embodiments, the capacitor is flexible and configured as a tube that

is disposed within the housing. Preferably, in either case, the capacitor is wrapped around the electrochemical device.

Preferably also, the electrochemical device is generally cylindrical and extends between two opposed axially spaced apart ends and the first capacitor extends axially away from one of the ends. More preferably, the energy storage device is of hollow construction with an aperture for receiving the electrochemical device. Even more preferably, the aperture receives both the electrochemical device and a second capacitor.

In a preferred form, the first capacitor is tubular and extends about the second capacitor and the electrochemical device.

According to another aspect of the invention there is provided an energy storage device including:

a housing having an interior and an exterior where the interior defines a cavity;

two terminals disposed on or adjacent to the exterior of the housing for electrically engaging with respective terminals of a load that requires a predetermined load current;

an electrochemical device disposed within the cavity and being electrically connected to the terminals for providing a first current to the load; and

a capacitor disposed within the cavity and being electrically connected to the terminals in parallel with the electrochemical device for providing a second current to the load, whereby the first current and the second currents collectively sum to the predetermined load current.

Preferably, the electrochemical device includes an anode and a cathode that are respectively fixedly electrically connected to the terminals by way of an anode tab and a cathode tab, and the capacitor includes a positive electrode and a negative electrode that are respectively fixedly electrically connected to the terminals by way of a positive electrode tab and a negative electrode tab. More preferably, the terminals extend from the interior to the exterior and the anode tab, the cathode tab, the positive electrode tab, and the negative electrode tab are disposed entirely within the cavity.

In a preferred form, the capacitor is an electric double layer supercapacitor including:

a capacitor housing;

a first and a second opposed sheet electrodes disposed within the housing and being respectively electrically connected to the terminals;

a separator located between the electrodes; and

an electrolyte intermediate the electrodes for allowing charge to be stored at the electrodes.

Preferably, the housing is flexible. More preferably, the energy storage device is flexible. In other embodiments, however, the housing and the electrochemical device are rigid and the capacitor is flexible and packed about the electrochemical device.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a schematic perspective view of an energy storage device according to the invention;

Figure 2 is a cross section taken along line 2-2 of Figure 1;

Figure 3 is a schematic plan view of the supercapacitor used in the device of Figure 1, where the supercapacitor is shown in the unwound configuration;

Figure 4 illustrates the supercapacitor of Figure 3 in a wound configuration prior to mounting to the housing;

Figure 5 is a chart illustrating the discharge profile for a prior art battery and an energy storage device according to the present invention;

Figure 6 is a schematic sectional view of another device according to the invention;

Figure 7 is a schematic plan view of an alternative supercapacitor;

Figure 8 is a plan view of another energy storage device according to the invention that is for use with a GSM telephone and which includes the supercapacitor of Figure 7; and

Figure 9 is a schematic cross sectional view taken along line 9-9 of Figure 8.

Referring to the drawings, and in particular to Figure 1 and Figure 2, there is illustrated an energy storage device 1. The device includes a cylindrical shrink wrap housing 2 having two opposed metal terminals 3 and 4. An electrochemical device in the form of a dry cell alkaline battery 5 is disposed within housing 2 for providing an electrical potential between the terminals. An electric double layer supercapacitor 6 is wrapped around and mounted to housing 2 and connected to terminals 3 and 4 in parallel with battery 5.

DETAILED DESCRIPTION OF THE INVENTION

As shown in Figure 3, supercapacitor 6 is formed from two like opposed rectangular aluminium sheet electrodes 10 which are maintained in a spaced apart overlying configuration by an intermediate separator 11. Each electrode includes a coating of activated carbon for providing a high surface area. Moreover, each electrode includes a protruding tab, which are separately numbered 15 and 16. The tabs includes respective central apertures 17 and are configured such that they protrude from opposite edges of the respective sheets.

The elements shown in Figure 3 are placed in a package with only tabs 15 and 16 protruding. An electrolyte is placed in the package before it is sealed. This arrangement is then wound to provide the tubular supercapacitor 6, as best shown in Figure 4. The supercapacitor is hollow and extends axially between a first end 19 and a second opposed end 20. Each of the ends includes an aperture 21.

The internal diameter of the supercapacitor is such as to complementarily receive battery 5, which is inserted through one of apertures 21. Moreover, ends 19 and 21 are axially spaced apart to be co-terminus with the adjacent ends of the battery. That is, supercapacitor 6 provides a sheath into which battery 5 is received. Once so received, tabs 17 and 18 are folded across respective adjacent apertures 21 and welded, soldered or otherwise electrically connected to the battery terminals such that battery 5 and supercapacitor 6 are connected in parallel. In this embodiment use is made of ultrasonic welding. It will be appreciated that the positive terminal of battery 5 includes a detent which is received by and which extends through aperture 17.

Thereafter shrink wrap 2 is applied and device 1 is ready for use. It will be appreciated that device 1, when wound, has a total wall thickness of about 0.2 mm. That is, device 1 only increases the diameter of the battery about which it is disposed by about 0.4 mm.

Supercapacitor 6 provides a capacitance of about 0.5 Farads and an esr of 10 milliohms. Accordingly, device 1 offers performance characteristics which are far superior to that of battery 5 alone. That is, in situations where pulse loading of device 1 occurs, a predominance of the energy provided will be from supercapacitor 5. This reduces the pulse load on battery 5 and, as such, allows the battery life to be extended. Moreover, between pulses battery 5 is able to recharge supercapacitor 6. That is, as the internal resistances of batteries are generally higher than the esr or equivalent series resistance of a capacitor or supercapacitor the use of such a capacitor or supercapacitor in parallel with the battery reduces the effective resistance of the resultant energy storage device.

Another preferred embodiment of the invention is illustrated in Figures 7, 8 and 9. More particularly, with reference to Figure 8, there is shown an energy storage device 41 including a hard plastics housing 42. Device 41 has two rectangular metal terminals 43 and 44 which are adjacent one another and a bottom edge 45 of the housing. Device 41 is selectively engaged by way of formations 46 and 47 with a GSM telephone (not shown). Moreover, terminal 43 and 44 are located to abut corresponding terminals on the telephone to allow energy transfer to the telephone.

Device 41 includes an electrochemical device in the form of a Li-Ion battery 48 disposed within housing 42 for providing an electrical potential between the terminals.

Battery 48 includes two electrode tabs 49 which electrically connect the respective positive and negative electrodes of the battery (not shown) to terminals 43 and 44.

A capacitor, in the form of a supercapacitor 50, is mounted internally to housing 42 and is electrically connected to terminals 43 and 44 in parallel with battery 48. That is, supercapacitor 50 includes two electrode tabs 51 that electrically connect the respective electrodes of the supercapacitor to terminals 43 and 44.

In the embodiment shown, tabs 51 are sandwiched between respective tabs 49 and terminal 43 and 44. In some embodiments the actual physical connection between the tabs and the terminals is effected by welding or soldering. In this specific embodiment, however, the connection is effected by ultrasonic welding.

As best shown in Figure 7, Supercapacitor 50 includes two electrodes 52 from which respectively extend tabs 51. The electrodes are generally rectangular and include respective carbon coatings that are opposed with each other. The electrodes are maintained in a fixed spaced apart configuration by a porous separator 53 that is non-conductive. The electrodes and the separator are contained within a sealed plastics laminar package 54 which contains an electrolyte for allowing ionic conduction between the electrodes. Tabs 51 extend from package 54 for connection with terminals 43 and 44, as discussed above.

In this embodiment, supercapacitor 50 is flexible to facilitate its incorporation into housing 42. This also allows supercapacitor 50 to be retro fitted into some existing housings. An example of the construction of such a flexible supercapacitor is disclosed in a copending PCT patent application numbered PCT/AU99/00780, the disclosure of which is included herein by way of cross reference.

In some embodiments the housing is specifically configured to accommodate a rigid supercapacitor.

Battery 48 includes a solid polymer electrolyte (not shown) which, while providing good energy density, places a severe limitation on the peak current that can be provided by the battery if damage is to be avoided. The combination of battery 48 and supercapacitor 50, however, is selected so that, for the currents loads experienced, they do not suffer this same disadvantage. That is, the low esr of supercapacitor 50 ensures that peak current demand will be substantially supplied by the supercapacitor. That is, supercapacitor 50 is providing an averaging effect on the battery current. In this case the peak battery current will be closer to the average battery current than would be the case in the absence of the supercapacitor.

Based upon the above teaching, it becomes clear that the capacitance of supercapacitor 50 has to be sufficient to provide the energy required by the load in a typical cycle. This will also assist in limiting the peak current of the battery to much less than the peak current demanded by the load.

This embodiment of the invention is particularly advantageous as it makes use of a simple parallel connection and involves no intervening and expensive control circuitry. In some embodiments, however, use is made of a switch (not shown) for selectively electrically isolating at least one of the tabs 51 from the respective terminal of device 41. This switch can be manually operated, although in other embodiments it is electrically operated by way of an IC.

As with many digital devices, the load that a GSM telephones presents to an energy supply device has a pulsed characteristic. This places a severe compromise on

such a supply that utilises a battery as its only source. That is, the battery has to be designed to achieve a reasonable power density which, in turn, compromises energy density. The present invention, however, limits that compromise.

To better illustrate this, reference is made to Figure 5. The first curve, labelled 22, shows the discharge characteristic of three serially connected prior art dry cell primary batteries under a pulse load such as that provided by a GSM mobile telephone. The voltage provided by the batteries is dependent not only upon the remaining energy stored but also on the size and duration of the pulsed load. In addition, the internal resistance of a battery generally increases with decreasing energy stored. Thus there is a threefold effect. Firstly as a result of high power pulses the battery looses energy or capacity due to I^2R energy losses. Secondly, as the energy stored in the battery becomes depleted, the I^2R energy losses increase. Thirdly, the voltage provided at the battery terminals decreases due to the IR drop as a result of the increased internal resistance of the battery, the increasing IR drop with increasing resistance, and the decreasing energy stored.

In the chart of Figure 5, the minimum operating voltage for the particular application is 3 Volts. In so far as the prior art device is concerned this minimum is reached quickly due to the three fold effect mentioned above.

An embodiment of the invention utilising series connected batteries of the same capacity, in parallel combination with respective series connected supercapacitors 6, provides the characteristic illustrated with curve 23. That is, the operational life of this embodiment is greater than that of the prior art as the I^2R losses, the voltage drop at the terminals of the device and the increase in battery internal resistance are less.

This is a direct result of supercapacitor 6 working in parallel with battery 5 to supply most of the energy required by the individual pulses at the time of the pulse. This, in turn, occurs due to the lower esr and large capacitance of supercapacitor 6 and the quantum of the energy drawn with each pulse. Due to the lower esr of supercapacitor 6 the voltage drop across the energy storage device during the pulse is small and certainly less than that suffered by the prior art device illustrated in curve 22.

As the internal resistance of the battery is not now of such concern, the battery is configured for maximum energy density rather than maximum power density. The supercapacitor accommodates the power requirements of the load which allows the battery to be designed for maximum energy density. This combination also provides an extended life for the preferred embodiments in comparison to corresponding prior art devices.

In another embodiment, illustrated in Figure 6 where corresponding features are denoted by corresponding reference numerals, a device 30 includes an electrolytic capacitor 31. This additional capacitor extends axially away from one end of battery 5 and is sheathed within supercapacitor 6. Capacitor 31 is connected in parallel with both battery 5 and supercapacitor 6. While capacitor 31 has a much smaller capacitance and similar or smaller esr to supercapacitor 6, it allows device 30 to accommodate extremely high frequency pulses without compromising the life of the battery.

Preferably, the external dimensions of device 30 correspond with the external dimensions of a prior art battery. For example, in one embodiment, device 30 has

external dimensions of a AA battery, although the battery 5 utilised within the device is an AAA cell.

In other embodiments, supercapacitor 6 is disposed wholly within the existing housing of the battery. In other embodiments, battery 5 and capacitor 31 are utilised without supercapacitor 6.

Although the supercapacitor and battery are shown as a single unit, they are, in some cases, separately obtained and combined by the user. Particularly in the Figure 1 embodiment, the supercapacitor can be retro fitted to an existing battery, whether or not that is a primary or a secondary cell.

The embodiments of the invention are particularly advantageously applied to pulsed load applications. Preferably, the esr and capacitance of the capacitor or supercapacitor used in parallel with the battery are selected based upon the characteristics of the load. Accordingly, while general purpose devices are also constructed, the invention allows economical tailoring of energy storage devices to load specific applications.

The use of a supercapacitor that is flexible has a number of advantages. For example, in some embodiments, the supercapacitor is combined in an existing housing with an existing rigid electrochemical cell. That is, the flexible nature of the supercapacitor allows it to be folded and/or wrapped about the electrochemical cell and to fill any available space in the housing rather than having to have a purpose specific space made available for it. Accordingly, cost and capital savings can be realised. In other embodiments, however, specific packaging is produced.

Another example of the benefits of the flexible packaging is obtained in those embodiments which also utilise flexible battery packaging, such as has been achieved with Li-Ion batteries that have solid polymer electrolytes. That is, the flexible packaging for the two different energy storage components can be selected to be similar, and in some cases, the same. Moreover, the common problem of electrolyte contamination is minimised as only one pair of terminals emerges from the package rather than two separate pairs as would be the case with separate packages. That is, the point of ingress of contaminants is greatest about the point of bonding between the terminals and the packaging.

The preferred embodiments of the invention that have been described above offer respective unitary energy storage devices that combines at least two different device types. These combinations provide:

- Improved energy supply characteristics, particularly to pulsed loads;
- Improved run-times for the electrical device, which is of considerable significance to portable devices such as mobile telephones and laptop computers;
- Peak current limiting for the battery - which extends battery lifetime and prevents damage to the battery;
- A single package for two separate types of storage devices, which adds considerable convenience to users of portable devices; and
- A combination of storage devices that will compatibly interact during both charge and discharge cycles.

Although the invention has been described with reference to specific examples it will be appreciated by those skilled in the art that it may be embodied in many other forms.

CLAIMS:-

1. An energy storage device including:

a housing having two terminals;

an electrochemical device disposed within the housing for providing an electrical potential between the terminals; and

a first capacitor mounted to the housing and being electrically connected to the terminals in parallel with the electrochemical device.

2. An energy storage device according to claim 1 wherein the capacitor extends about the housing.

3. An energy storage device according to claim 2 wherein the housing is cylindrical and extends between two opposed axially spaced apart ends, whereby the ends define respective terminals and the capacitor extends about the housing intermediate the ends.

4. An energy storage device according to claim 1 wherein the capacitor is an electric double layer supercapacitor including:

a capacitor housing;

a first and a second opposed sheet electrodes disposed within the housing and being respectively electrically connected to the terminals;

a separator located between the electrodes; and

an electrolyte intermediate the electrodes for allowing charge to be stored at the electrodes.

5. An energy storage device according to claim 1 wherein the capacitor is flexible and wrapped about the housing.

6. An energy storage device according to claim 1 wherein the capacitor is flexible and configured as a tube that is disposed within the housing.

7. An energy storage device according to claim 1 wherein the capacitor is wrapped around the electrochemical device.

8. An energy storage device according to claim 1 wherein the electrochemical device is generally cylindrical and extends between two opposed axially spaced apart ends and the first capacitor extends axially away from one of the ends.

9. An energy storage device according to claim 8 including a second capacitor which has an aperture for receiving the electrochemical device.

10. An energy storage device according to claim 9 wherein the aperture receives both the electrochemical device and the first capacitor.

11. An energy storage device according to claim 9 wherein the second capacitor is tubular and extends about the first capacitor and the electrochemical device.

12. An energy storage device according to claim 1 wherein the electrochemical device is a battery and the capacitor is an electric double layer supercapacitor.

13. An energy storage device according to claim 12 wherein the battery is a Li-Ion battery.

14. An energy storage device according to claim 13 wherein the Li-Ion battery includes a solid electrolyte.

15. An energy storage device according to claim 14 wherein the electrolyte includes a polymer.

16. An energy storage device according to claim 1 wherein the electrochemical device and the capacitor each include a pair of electrodes that are electrically connected to the respective terminals.

17. An energy storage device according to claim 16 wherein the electrodes are fixedly connected to the respective terminals.

18. An energy storage device according to claim 16 wherein at least one of the electrodes of the supercapacitor are selectively electrically isolated from the terminals.

19. An energy storage device according to claim 18 including a switch that is electrically disposed between one of the terminals and one of the electrodes of the capacitor for effecting the selective electrical isolation.

20. An energy storage device according to claim 1 wherein the electrochemical device and the capacitor each include a power density and an energy density, wherein the energy density of the electrochemical device is greater than the energy density of the capacitor and the power density of the electrochemical device is less than the power density of the capacitor.

21. An energy storage device including:

a housing having two terminals; and

a first capacitor forming part of the housing and connected to the terminals.

22. An energy storage device according to claim 21 wherein the housing has a form factor corresponding or being related to battery size designations N, AAAA, AAA, AA, C or D.

23. An energy storage device according to claim 21 wherein an electrochemical device is disposed within the housing for providing electrical energy to the terminals.

24. An energy storage device according to claim 21 wherein the device extends about the housing.

25. An energy storage device according to claim 21 wherein the housing is cylindrical and extends between two opposed axially spaced apart ends, whereby the ends define respective terminals and the capacitor extends about the housing intermediate the ends.

26. An energy storage device according to claim 21 wherein the capacitor is an electric double layer supercapacitor including:

a capacitor housing;

a first and a second opposed sheet electrodes disposed within the housing and being respectively electrically connected to the terminals;

a separator located between the electrodes; and

an electrolyte intermediate for allowing charge transfer between the electrodes.

27. An energy storage device according to claim 21 wherein the capacitor is flexible and wrapped about the housing.

28. An energy storage device according to claim 21 wherein the capacitor is flexible and configured as a tube that is disposed within the housing.

29. An energy storage device according to claim 21 wherein the capacitor is wrapped around the electrochemical device.

30. An energy storage device according to claim 21 wherein the electrochemical device is generally cylindrical and extends between two opposed axially spaced apart ends and the first capacitor extends axially away from one of the ends.

31. An energy storage device according to claim 21 wherein the energy storage device is of hollow construction with an aperture for receiving the electrochemical device.

32. An energy storage device according to claim 31 wherein the aperture receives both the electrochemical device and a second capacitor.

33. An energy storage device according to claim 32 wherein the first capacitor is tubular and extends about the second capacitor and the electrochemical device.

34. An energy storage device including:

a housing having an interior and an exterior where the interior defines a cavity;

two terminals disposed on or adjacent to the exterior of the housing for electrically engaging with respective terminals of a load that requires a predetermined load current;

an electrochemical device disposed within the cavity and being electrically connected to the terminals for providing a first current to the load; and

a capacitor disposed within the cavity and being electrically connected to the terminals in parallel with the electrochemical device for providing a second current to the load, whereby the first current and the second currents collectively sum to the predetermined load current.

35. An energy storage device according to claim 34 wherein the electrochemical device includes an anode and a cathode that are respectively fixedly electrically connected to the terminals by way of an anode tab and a cathode tab, and the capacitor includes a positive electrode and a negative electrode that are respectively fixedly

electrically connected to the terminals by way of a positive electrode tab and a negative electrode tab.

36. An energy storage device according to claim 35 wherein the terminals extend from the interior to the exterior and the anode tab, the cathode tab, the positive electrode tab, and the negative electrode tab are disposed entirely within the cavity.

37. An energy storage device according to claim 34 wherein the capacitor is an electric double layer supercapacitor including:

a capacitor housing;

a first and a second opposed sheet electrodes disposed within the housing and being respectively electrically connected to the terminals;

a separator located between the electrodes; and

an electrolyte intermediate for allowing charge transfer between the electrodes.

38. An energy storage device according to claim 36 wherein the housing is flexible.

39. An energy storage device according to claim 38 wherein the energy storage device is flexible.

40. An energy storage device according to claim 36 wherein the housing and the electrochemical device are rigid and the capacitor is flexible and packed about the electrochemical device.

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(71) Applicant *(for all designated States except US)*: **ENERGY STORAGE SYSTEMS PTY LTD** [AU/AU]; Riverside Corporate Park, Building 5, (Gate 4), 105 Delhi Road, North Ryde, NSW 2113 (AU).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: **MAHON, Peter, John** [AU/AU]; 8/45 Meadow Crescent, Meadowbank, NSW 2114 (AU).

(74) Agent: **BALDWIN SHELSTON WATERS**; 60 Margaret Street, Sydney, NSW 2000 (AU).

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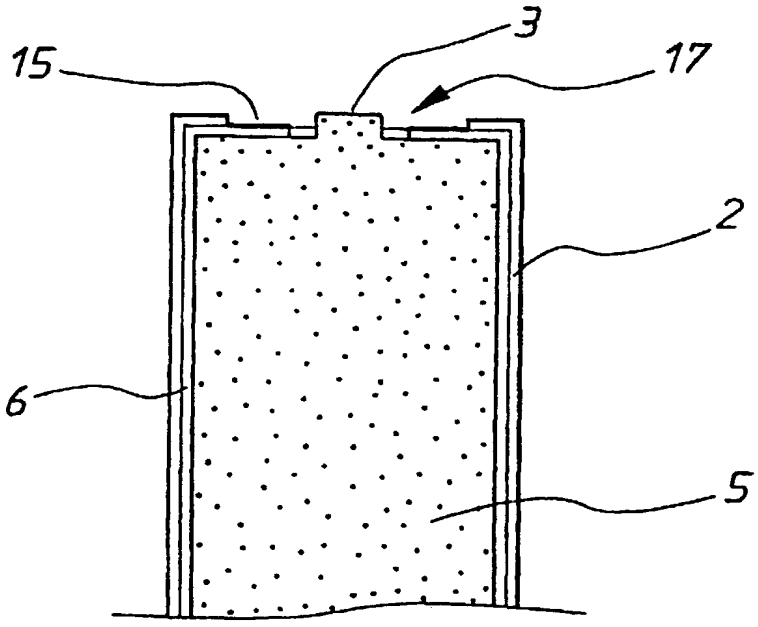
(54) Title: AN ENERGY STORAGE DEVICE



(57) Abstract: An energy storage device (1) includes a cylindrical shrink wrap housing (2) having two opposed metal terminals (3, 4). An electrochemical device in the form of a dry cell alkaline battery (5) is disposed within housing (2) for providing an electrical potential between the terminals. An electric double layer supercapacitor (6) is wrapped around and mounted to housing (2) and connected to terminals (3, 4) in parallel with battery (5).

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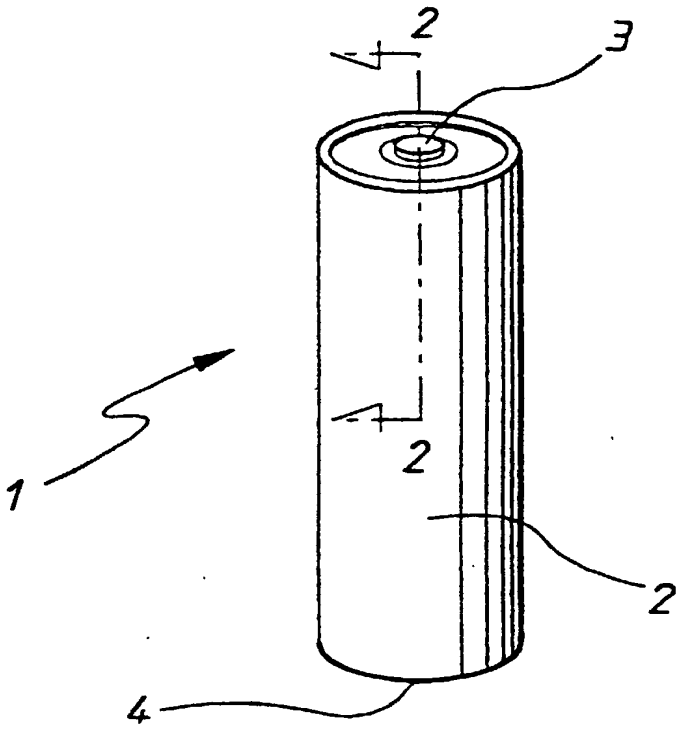

FIG. 1

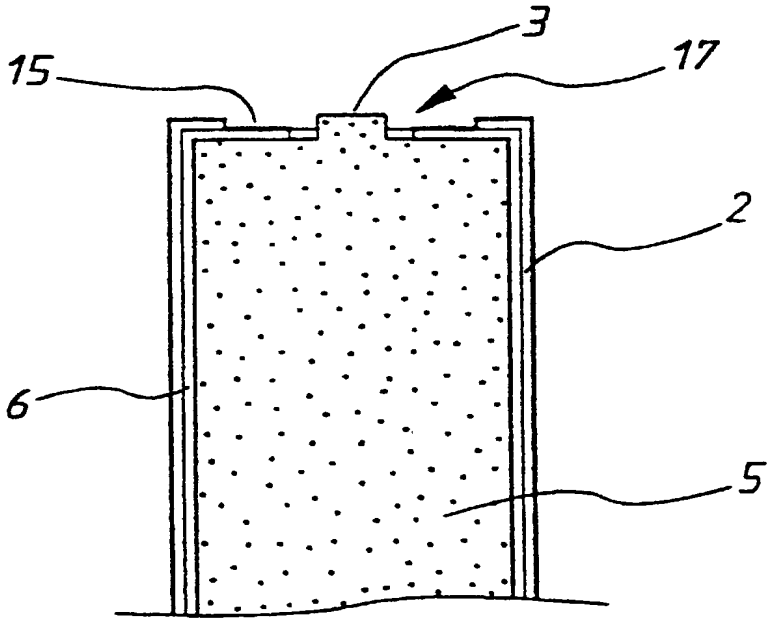

FIG. 2

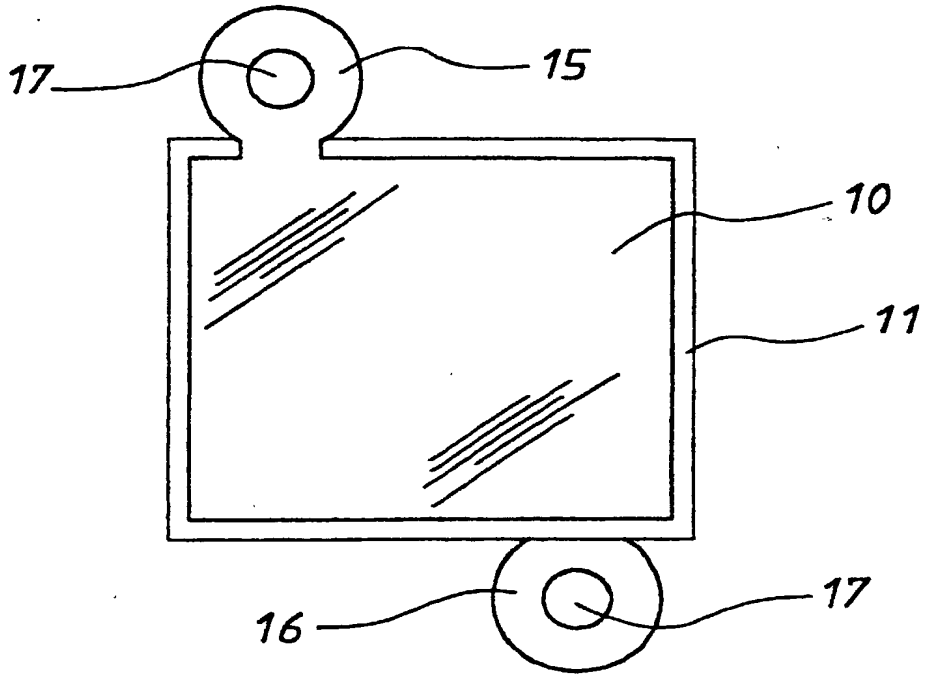

FIG.3

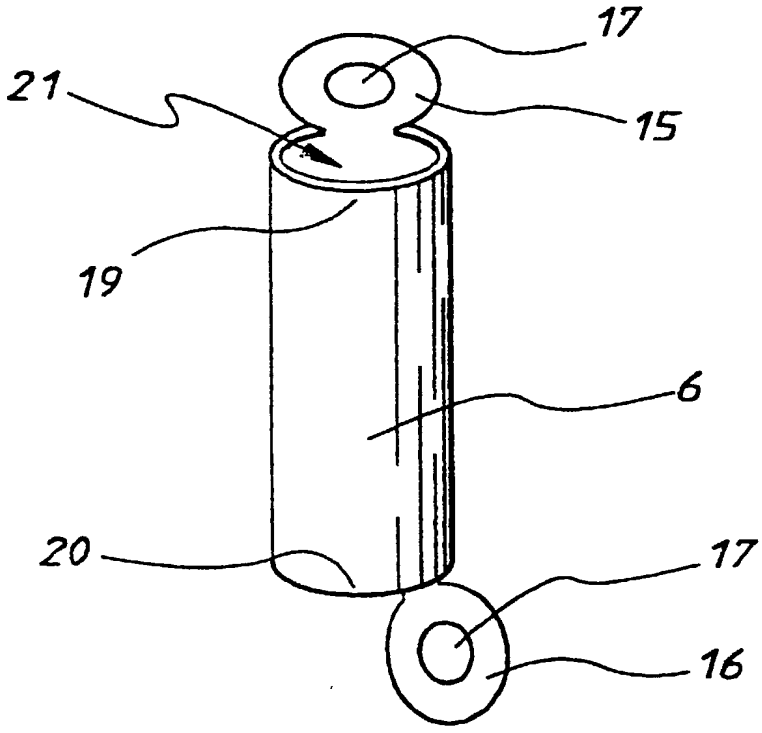

FIG.4

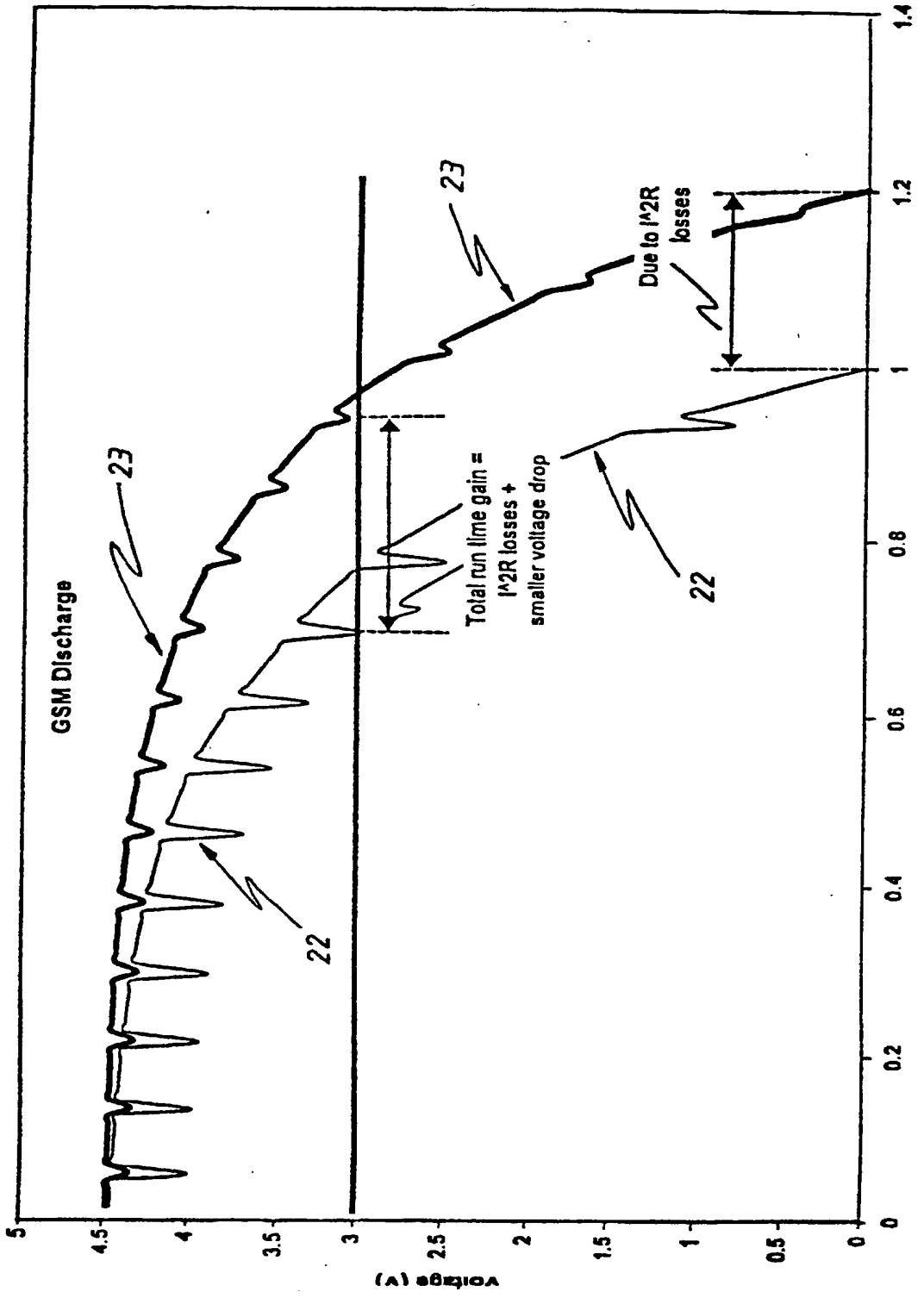
GSM Discharge
23
22
Total run time gain = I^2R losses + smaller voltage drop
23
Due to I^2R losses
22
Voltage (V)
Units of Time
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4

FIG. 5

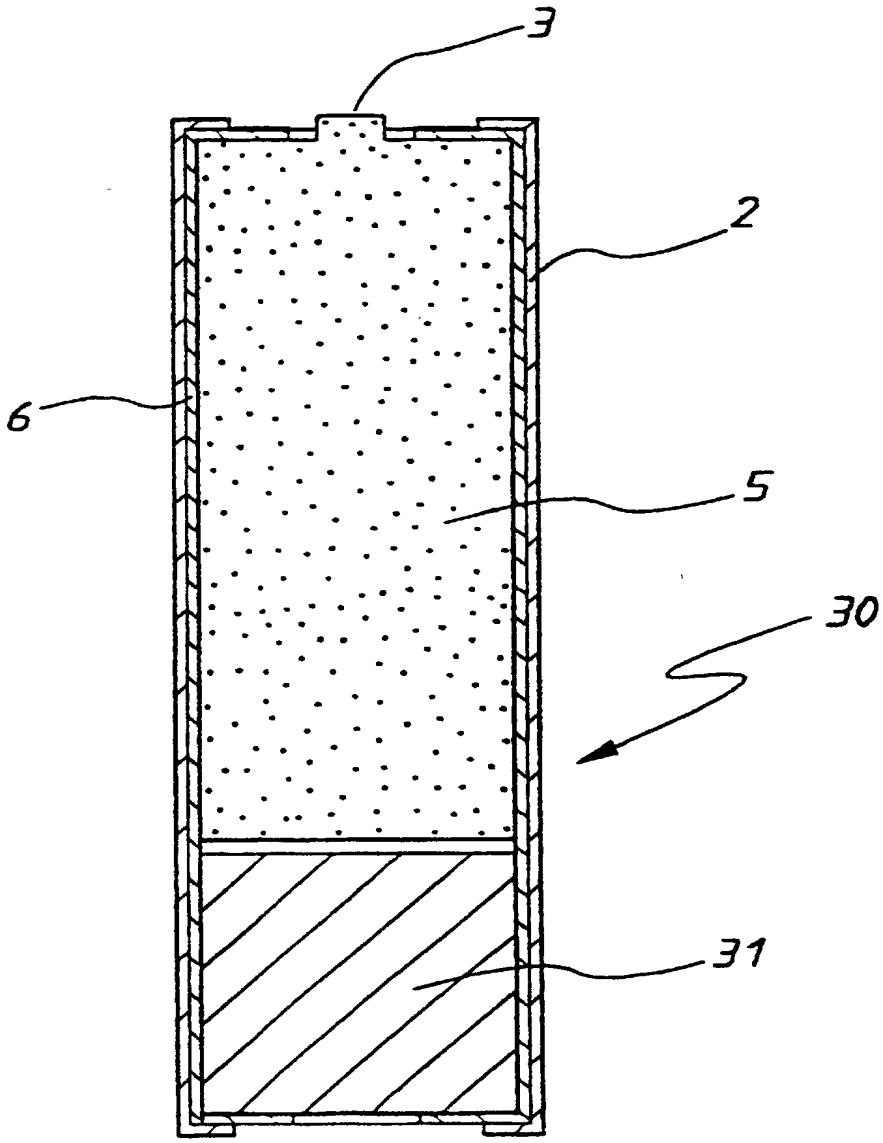

FIG.6

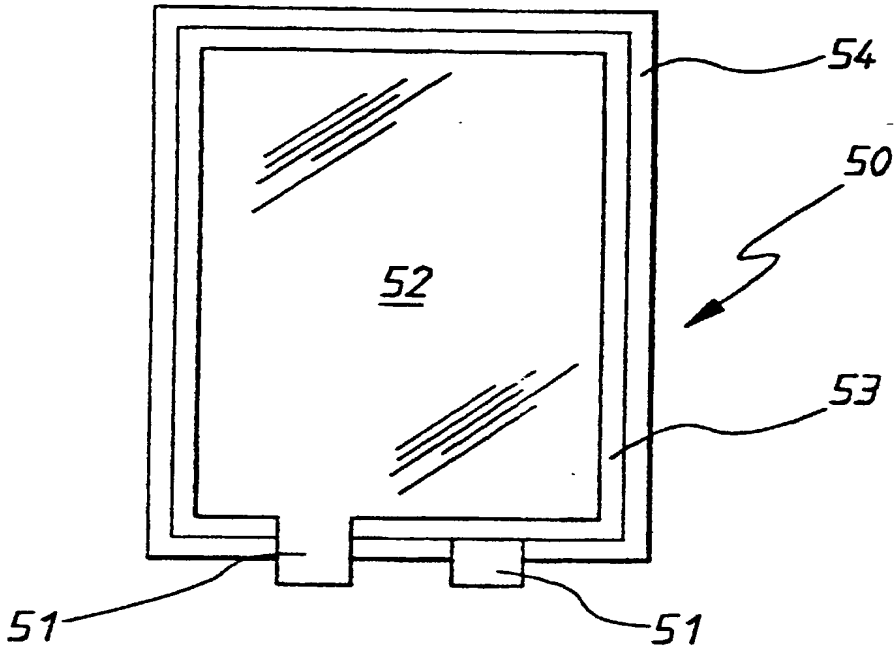

FIG.7

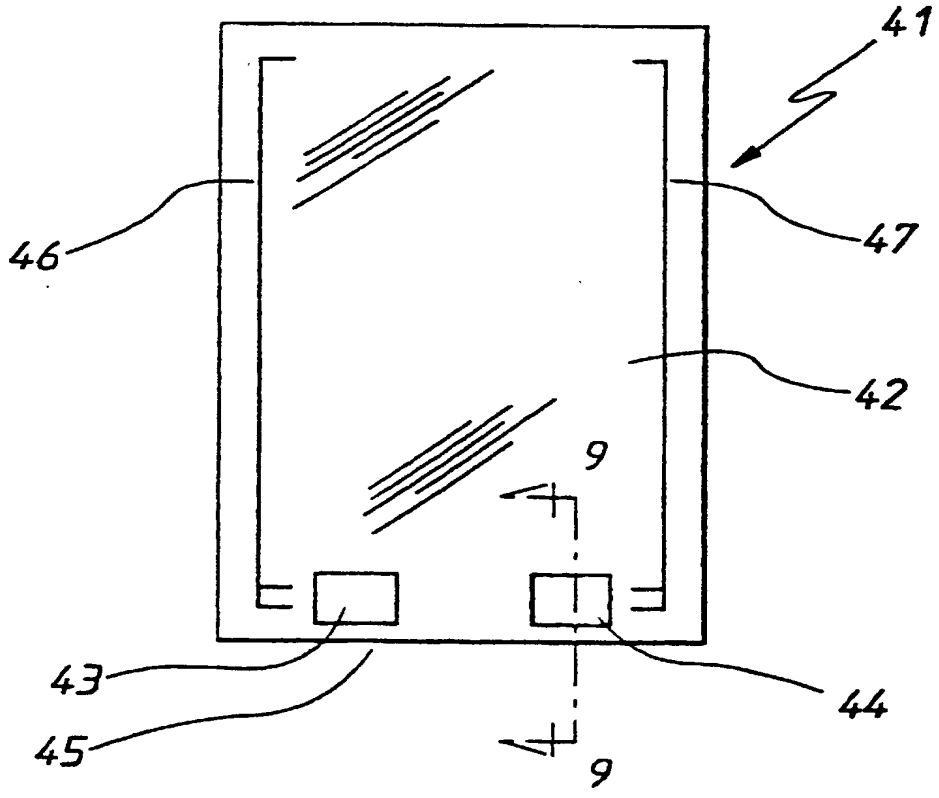

FIG.8

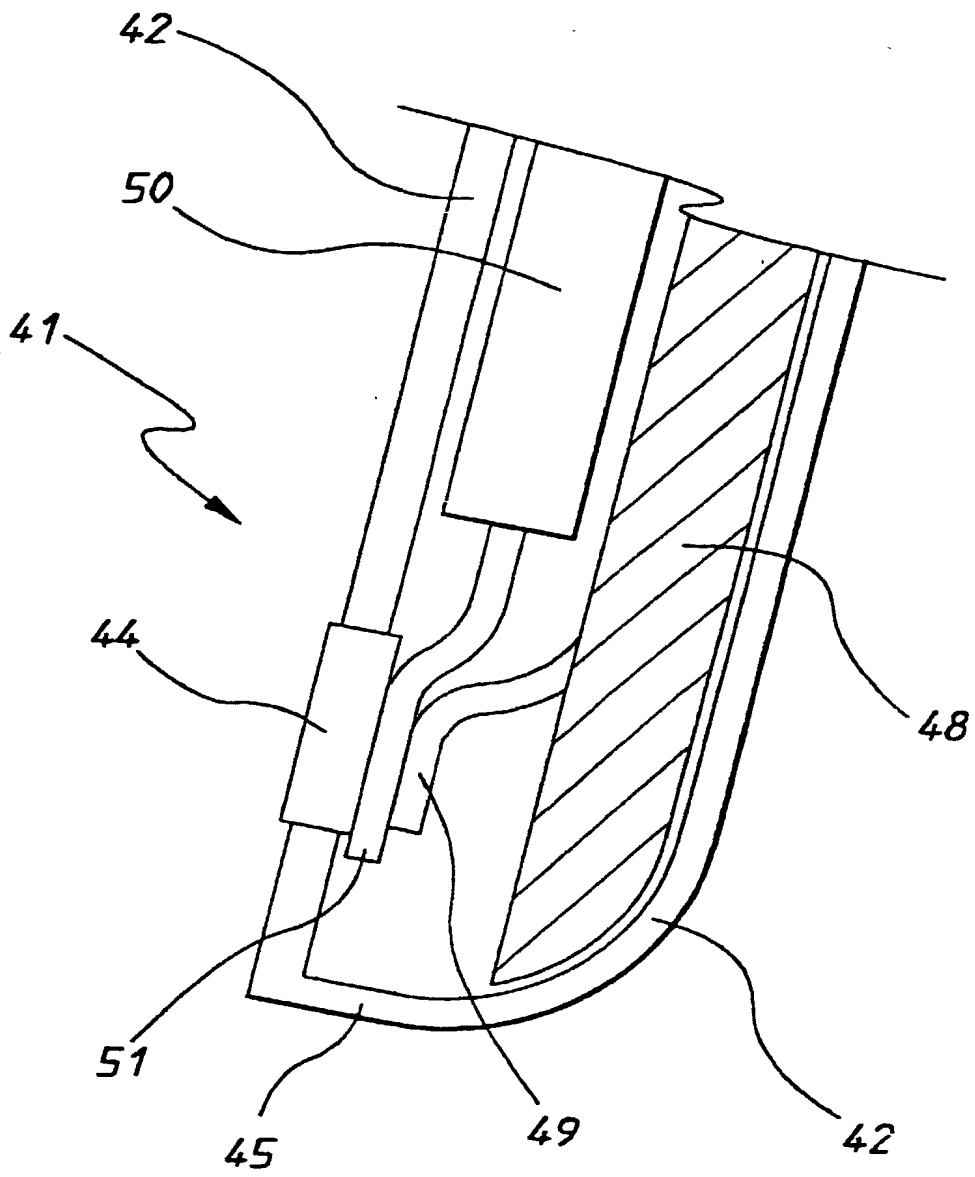

FIG.9

Attorney Docket: 11848/4

DECLARATION AND POWER OF ATTORNEY

As the below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled AN ENERGY STORAGE DEVICE

the specification of which (check one):

_____ is attached hereto

or

__X__ was filed on 12 July 2000 as PCT International Application No. PCT/AU00/00836, and 28 December 2001 as U.S. Application No. 10/019237

__X__ was amended on 28 December 2001.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to the patentability of this application, as defined in 37 C.F.R. §1.56.

I hereby claim foreign priority benefits under Title 35 United States Code §119(a)-(d) of any foreign application(s) for patent or inventor's certificate, or §365(a) of any PCT international application which designated at least one country other than the United States of America, listed below. I have also identified below any foreign application for patent or inventor's certificate, or any PCT international application having a filing date before that of the application on which priority is claimed.

Appl. Serial No./ Country	Filing Date	Status	Priority Claimed
PQ1578	12 July 1999		Yes: X No:
PQ1602	13 July 1999		Yes: X No:

_____ *Additional foreign applications are listed on an attached supplemental priority data sheet.*

I hereby claim the benefit under Title 35, United States Code §120, of any United States applications or §365(c) of any PCT international application designating the United States of America listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in those prior applications in the manner provided by the first paragraph of Title 35, United States Code §112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, §1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

U.S. / PCT Appl.. Serial No.	Filing Date	Status/Patent No.	Priority Claimed
			Yes: No:
			Yes: No:

_____ *Additional U.S. / PCT applications are listed on an attached supplemental priority data sheet.*

I hereby claim the benefit under Title 35, United States Code §119(e), of any United States provisional applications listed below :

Application Number	*Filing Date*

And I hereby appoint the registered practitioners of Kenyon & Kenyon included in the Customer Number provided below to prosecute this application and transact all business in the Patent and Trademark Office connected therewith:

23838

Please address all correspondence to the above Customer Number.

I hereby declare that all statements made herein of our own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

First Inventor : Peter John MAHON

Inventor's Signature : P.J. Mahon

Date : 3/5/02

Residence : ~~8/45 Meadow Crescent~~ 26/51 LEAHY CLOSE
~~Meadowbank, New South Wales~~ NARRABUNDAH, ACT 2604
~~2114 AUSTRALIA~~ AUSTRALIA

Citizenship : AUSTRALIAN (AUX)

Post Office Address : Same as above